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FOR

METHOD AND MECHANISM OF PZT MICRO-ACTUATOR ATTACHMENT FOR THE HARD DISK DRIVER ARM

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METHOD AND MECHANISM OF PZT MICRO-ACTUATOR ATTACHMENT FOR THE HARD DISK DRIVER ARM

Background Information

[0001] The present invention relates to magnetic hard disk drives. More specifically, the present invention relates to a method of assembling micro-actuators.

[0002] In the art today, different methods are utilized to improve recording density of hard disk drives. **Figure 1** provides an illustration of a typical disk drive. The typical disk drive has a head gimbal assembly (HGA) configured to read from and write to a magnetic hard disk 101. The HGA and the magnetic hard disk 101 are mounted to the base 102 of a main board 103. The disk 101 is rotated relative to the base 102 by a spindle motor 104. The HGA typically includes an actuator arm 105 and a load beam 106. The HGA supports and positions a magnetic read/write slider 107 above the magnetic hard disk 101. The HGA is rotated relative to the base 102 along the axis of a bearing assembly 108 by a voice coil motor 109. A relay flexible printed circuit 110 connects a board unit 111 to the magnetic read/write slider 107.

[0003] **Figures 2a-d** provide an illustration of two embodiments of a piezoelectric micro-actuator. **Figure 2a** illustrates a micro-actuator with a U-shaped ceramic frame configuration 201. The frame 201 may be Zirconia. The frame 201 may have two arms 202 opposite a base 203. A slider 204 may be held by the two arms 202 at the end opposite the base 203. A strip of piezoelectric material 205 may be attached to each arm 202. **Figure 2b** illustrates the micro-actuator as attached to an actuator suspension 206. The micro-actuator may be coupled to a suspension tongue 207. Traces 208, coupled along the suspension 206, apply a voltage to the

strips of piezoelectric material 205. These voltages may cause the strips 205 to contract and expand, moving the placement of the slider 204.

[0004] **Figure 2c** illustrates an alternate version of the micro-actuator. In this embodiment, a metallic frame 209 has a base 210 with two arms 211 perpendicular to the plane of the base 210. A slider support 212 may hold the slider between the two arms 211. A strip of piezoelectric material 213 is coupled to each arm 211. The micro-actuator may then be attached to the head suspension 206 in the same manner as the ceramic micro-actuator, as shown in **Figure 2d**.

[0005] One embodiment of a method of manufacturing the metallic frame 209 is shown in **Figures 3a-d**. The frame 209 may be stainless steel, such as SUS304. As shown in **Figure 3a,** the two arms 211 of the metallic frame 209 may be formed using vertical forming by machine or laser. A hole 301 may be formed on the slider support 212 to facilitate the slider 204 mounting. The support connections 302 and the base connections 303 may be narrowed to improve resonance. The two strips of piezoelectric material 213 may each have at least one contact pad 304 attached that allows the strips 213 to be electrically coupled to a control circuit. As shown in **Figure 3b**, the strips 213 may be coupled to the arms 211 of the metallic frame 209. As shown in **Figure 3c**, the slider 204 may be coupled to the slider support 212. The slider 204 may be coupled using epoxy or some other kind of adhesive. The epoxy may be cured using the hole 301 in the slider support 212. As shown in **Figure 3d,** the micro-actuator may then be attached to the suspension tongue 207.

[0006] **Figures 4a-b** provides an illustration in a pair of charts of the effect of adhesive thickness on stroke and resonance. **Figure 4a** compares the stroke in micrometers to the adhesive thickness in millimeters. In this example, stroke pertains to the amount of deflection of the slider caused by the micro-actuator. **Figure 4b** compares the resonance frequency of the micro-actuator in kilohertz to the adhesive thickness in millimeters. Due to the small size of the micro-actuators and the fragile nature of the piezoelectric material, stress fractures and distortions remain problems.

Brief Description Of The Drawings

[0007] **Figure 1** provides an illustration of a typical disk drive.

[0008] **Figures 2a-d** provide an illustration of two embodiments of a piezoelectric micro-actuator.

[0009] **Figures 3a-d** provide an illustration of one embodiment of a method of manufacturing the metallic frame.

[0010] **Figures 4a-b** provide an illustration in a pair of charts of the effect of adhesive thickness on stroke and resonance.

[0011] **Figures 5a-e** provide an illustration of one embodiment of a method for attaching the strips of piezoelectric material to the metallic frame.

[0012] **Figure 6** provides an illustration in a flowchart of one embodiment of a method for using the fixture

[0013] **Figures 7a-e** provide an illustration of an alternate embodiment of a method for attaching the strips of piezoelectric material to multiple metallic frames.

[0014] **Figures 8a-f** provide an illustration of an alternate embodiment of a method for attaching the strips of piezoelectric material to the metallic frame.

[0015] **Figures 9a-e** provide an illustration of an alternate embodiment of a method for attaching the strips of piezoelectric material to the metallic frame.

Detailed Description

[0016] A fixture with a shaped molding may hold a first micro-actuator part and a second micro-actuator part in place for coupling while maintaining the structure of the first micro-actuator part. The first micro-actuator part and the second micro-actuator part may be a frame or a strip of piezoelectric material. A vacuum nozzle system embedded in the fixture may hold the first micro-actuator part in place. A mobile vacuum nozzle system may hold the second micro-actuator in place and positions the second micro-actuator part relative to the first micro-actuator part. A camera system may monitor the process. A dispenser may apply epoxy between the first and second micro-actuator part. An ultraviolet source may provide ultraviolet radiation for curing.

[0017] **Figures 5a-e** illustrate one embodiment of a method for attaching the strips of piezoelectric material 213 to the metallic frame 209. As shown in **Figure 5a**, the metallic frame 209 may be placed on a fixture 501 to maintain the structure of the metallic frame 209 while the strips of piezoelectric material 213 are added. The fixture 501 may have a shaped indentation 502 to match the exterior of the metallic frame 209. Alternately, the fixture 501 may have a shaped protrusion that matches the interior of the metallic frame 209. A vacuum nozzle 503 embedded within the fixture 501 may hold the metallic frame 209 in place on the fixture 501. The base 210 may be placed on the vacuum nozzle 503. As shown in **Figure 5b**, a strip of piezoelectric material 213 may be held aloft by a mobile vacuum nozzle 504. The mobile vacuum nozzle 504 may be moved in all three dimensions and is rotatable along the axis of the nozzle 504. A camera system 505 may be used to monitor the placement of the strip of

piezoelectric material 213. A dispenser places adhesive on the metallic frame 209. In one embodiment, the adhesive is epoxy. As shown in **Figure 5c**, the mobile vacuum nozzle 504 may place the strip of piezoelectric material 213 against the metallic frame 209. An ultraviolet source 506 may be used to cure the epoxy bond between the strip of piezoelectric material 213 and the metallic frame 209. After a time delay of 3-9 seconds, the ultraviolet source 506 is turned off and the mobile vacuum nozzle 504 is removed. In an alternate embodiment, the mobile vacuum nozzle 504 is removed and the ultraviolet source 506 is turned off. In an alternative embodiment illustrated in **Figure 5d**, the fixture 501 may maintain the structure of multiple metallic frames 209. The mobile vacuum nozzle 504 may place the strip of piezoelectric material 213 against the arm 211 of the first metallic frame 209. As shown in **Figure 5e**, the ultraviolet source 506 may then cure the epoxy bond before moving to the next metallic frame 209.

[0018] One embodiment of a method for using the fixture of **Figures 5d-e** is illustrated in the flowchart of **Figure 6**. To start (Block 605), the frame 209 may be laminated (Block 610). The frame 209 may be placed upon the fixture 501 (Block 615). The strip of piezoelectric material 213 may be picked up by the mobile vacuum nozzle 504 (Block 620). The location of the strip of piezoelectric material 213 may be confirmed and then adjustments are made as necessary (Block 625). Epoxy may be added to the frame 209 (Block 630). The strip of piezoelectric material 213 may be attached to the frame 209 (Block 635). The epoxy is cured by ultraviolet radiation (Block 640). A camera system 505 may confirm if further frames 209 are on the fixture 501 (Block 645). If further frames 209 are not on the fixture 501, the fixture 501 is exchanged (Block 650). Otherwise, the next frame is worked on (Block 610).

[0019] **Figures 7a-e** illustrate an alternate embodiment of a method for attaching the strips of piezoelectric material 213 to multiple metallic frames 209. As shown in **Figure 7a**, a first metallic frame 209 is placed on a first fixture 701 and a second metallic frame 209 is placed on the second fixture 702 to maintain the structure of the metallic frames 209 while the strips of piezoelectric material 213 are added. The first fixture 701 and the second fixture 702 may have shaped indentations 703 to match the exterior of the metallic frame 209. Alternately, the first fixture 701 and the second fixture 702 may have a shaped protrusion that matches the interior of the metallic frame 209. A first vacuum nozzle 704 embedded within the first fixture 701 may hold a metallic frame 209 in place on the first fixture 701 and a second vacuum nozzle 705 embedded within the first fixture 702 may hold a metallic frame 209 in place on the second fixture 702. As shown in **Figure 7b**, two strips of piezoelectric material 213 may be held aloft by a mobile dual vacuum nozzle 706. The mobile dual vacuum nozzle 706 may be moved in all three dimensions. A camera system 505 may be used to monitor the placement of the strip of piezoelectric material 213. A dispenser places adhesive on the metallic frame 209. In one embodiment, the adhesive is epoxy. As shown in **Figure 7c**, the mobile dual vacuum nozzle 706 may place the strips of piezoelectric material 213 against the metallic frames 209. A first ultraviolet source 707 and a second ultraviolet source 708 may be used to cure the epoxy bonds between the strips of piezoelectric material 213 and the metallic frames 209. After a time delay of 3-9 seconds, the mobile dual vacuum nozzle 706 is removed and the first ultraviolet source 707 and the second ultraviolet source 708 are turned off. In an alternative embodiment illustrated in **Figure 7d**, the first fixture 701 and the second fixture 702 may each maintain the

structure of multiple metallic frames 209. The mobile dual vacuum nozzle 706 may place the strip of piezoelectric material 213 against the arm 211 of a first and second metallic frame 209. As shown in **Figure 7e**, the first ultraviolet source 707 and the second ultraviolet source 708 may then cure the epoxy bond before moving to the next two metallic frames 209.

[0020] **Figures 8a-f** illustrate an alternate embodiment of a method for attaching the strips of piezoelectric material 213 to the metallic frame 209. As shown in **Figure 8a**, the two strips of piezoelectric material 213 may be placed on the fixture 801. The fixture 801 may have a shaped indentation 802 to match the exterior of the metallic frame 209 and the two strips of piezoelectric material 213. A vacuum nozzle system 803 embedded within the fixture 501 may hold the two strips of piezoelectric material 213 in place on the fixture 801. As shown in **Figure 8b**, a frame 209 may be held aloft by a mobile vacuum nozzle 804, with the arms oriented downward. The mobile vacuum nozzle 804 may be moved in all three dimensions and is rotatable along the axis of the nozzle 804. A camera system 805 may be used to monitor the placement of the frame 209. As shown in **Figure 8c,** a first dispenser 806 and a second dispenser 807 may place adhesive on the metallic frame 209. In one embodiment, the adhesive is epoxy. As shown in **Figure 8d,** the mobile vacuum nozzle 804 may move about to spread the epoxy evenly on the frame 209. As shown in **Figure 8e,** the mobile vacuum nozzle 804 may place the metallic frame 209 against the strip of piezoelectric material 213. As shown in **Figure 8f,** a first ultraviolet source 808 and a second ultraviolet source 809 may be used to cure the epoxy bond between the strip of piezoelectric material 213 and the metallic frame 209. After a time delay of 3-9 seconds, the mobile vacuum nozzle 804 may be removed after the first

ultraviolet source 808 and the second ultraviolet source 809 are turned off. In an alternate embodiment, the mobile vacuum nozzle 804 may be removed before the first ultraviolet source 808 and the second ultraviolet source 809 are turned off.

[0021] **Figures 9a-e** illustrate an alternate embodiment of a method for attaching the strips of piezoelectric material 213 to the metallic frame 209. As shown in **Figure 9a**, the two strips of piezoelectric material 213 may be placed on the fixture 801. The fixture 801 may have a shaped indentation 802 to match the exterior of the metallic frame 209 and the two strips of piezoelectric material 213. A vacuum nozzle system 803 embedded within the fixture 501 may hold the two strips of piezoelectric material 213 in place on the fixture 801. A frame 209 may be held aloft by a mobile vacuum nozzle 804, with the arms oriented upward. The mobile vacuum nozzle 804 may be moved in all three dimensions and is rotatable along the axis of the nozzle 804. A camera system 805 may be used to monitor the placement of the frame 209. As shown in **Figure 9b,** a first dispenser 806 and a second dispenser 807 may place adhesive on the metallic frame 209. In one embodiment, the adhesive is epoxy. As shown in **Figure 9c**, the mobile vacuum nozzle 804 may move about to spread the epoxy evenly on the frame 209. As shown in **Figure 9d**, the mobile vacuum nozzle 804 may place the metallic frame 209 against the strip of piezoelectric material 213. As shown in **Figure 9e,** a first ultraviolet source 808 and a second ultraviolet source 809 may be used to cure the epoxy bond between the strip of piezoelectric material 213 and the metallic frame 209. After a time delay of 3-9 seconds, the mobile vacuum nozzle 804 may be removed after the first ultraviolet source 808 and the second ultraviolet 809 may be turned off. In an alternate embodiment, the mobile vacuum nozzle 804

may be removed before the first ultraviolet source 808 and the second ultraviolet source 809 are turned off.

[0022] Although several embodiments are specifically illustrated and described herein, it will be appreciated that modifications and variations of the present invention are covered by the above teachings and within the purview of the appended claims without departing from the spirit and intended scope of the invention.